Heath audio generator
Experiments

IG 72 (66)

other formulas derived

Transformation of π networks for f, $\frac{R_g}{R_L}$, Q

$L \propto \frac{1}{freq}$

$X_L = \frac{Q\,2R_g}{Q^2\sqrt{R_g/R_L}} = \frac{2R_g}{Q\sqrt{R_g/R_L}}$

$\frac{4R_g \cdot R_L}{Q^2 R_g} = \frac{2\sqrt{50}}{2} = \frac{7}{3} = 47\Omega$

$L = \frac{X_L}{2\pi f} = \frac{2Q R_g X_L}{Q^2 2\pi f \sqrt{R_g/R_L}} = \frac{2R_g X_L}{Q\,2\pi f \sqrt{R_g/R_L}}$

$X_L = \frac{2\sqrt{R_L}}{Q} = \frac{2}{5} \times 33 =$

$X_L^2 = \frac{4R_g^2 \cdot R_L}{Q^2 R_g}$ = $X_L = \frac{2\sqrt{R_g R_L}}{Q} = \frac{2\sqrt{80 \cdot 50}}{3} = 42\Omega$ ✓

$L = \frac{1}{2\pi f X_L} = \frac{3}{4\pi f \sqrt{R_g R_L}} = \frac{0.239}{7\times10^6 \times \sqrt{80\cdot50}} = .0054 \times$

$\sqrt{80\cdot50} = 63.4$, $7\times10^6 \times 63.4 = 444\times10^6$

$L = \frac{X_L}{2\pi f} = \frac{2\sqrt{R_g R_L}}{Q \times 6.28\, f} = \frac{0.318}{Q f} \times \sqrt{R_g R_L} =$

$= \frac{0.318 \times 63.4}{3 \times 7 \times 10^6} = 0.96\times10^{-6}\,H$ ✓

Conclusion: ① L is proportional to geometric mean of R_g + R_L, inversely proportional to Q and frequency } 4 variables

② C_1 + C_2 are proportional to L

③ C_1/C_2 proportional to $\sqrt{R_L/R_g}$

4. ~~C_1 if C_2 proportional to L~~

Transform

80 { 970 / 1,220 } 50 to 230 { 0.95 / 33 }

7mc Q3 f=25 Mcps Q5

$L = \frac{87.}{1220} \times \frac{3}{5} \times \frac{7000000}{251} \times 0.95\times10^{-6} = \frac{4400 \times 0.95\,PF}{75{,}000} = \frac{174{,}000{,}000}{75{,}000} = 23{,}200 \times 10^{-6} = 23.2\,MH$

$XC_{Total} = X_L$

Note: Use 22 MH as is and electrolytic cap in series opposing $\frac{1}{\frac{1}{130}+\frac{1}{130}} = \frac{1}{66}$ MF NON POLAR

or (2) rewind Toroid to 1 MH to use 1.1 MF and 3 MF

or (3) ~~rewind Toroid to 5.5 MH to double as 2:1 Ap. Trans. to 2 ohm~~ rewind 22 MH to serve as primary 1:0.38 x former and also as 3.14 MH π inductor for $L = 22$ MH ← L+C inversely proportional, L ≈ Q

π net Heath audio generator

3/73 (p 2 of 3)

30.3ST · 3.6 MF and 9.4 MF at MF

3.14 MH. 25. C_1 C_2 Lamp No 49 33 Ω

230 Ω f = 25 kcps 66 MF

R_g 230 Ω, f = 25 kc/s

given $R_g = 230\,\Omega$, $R_L = 33\,\Omega$

Max f of gen = 100 kc/s Q unloaded = 30

Choose f = 25 kc

2 MH 2.3 6 25 kc

X_L 3.48

R_g 230 Ω X_1 R_1 3.48 X_2 R_2 3.48 $R_L = 33\,\Omega$

$(Q \text{ of } X_1 R_1)(Q \text{ of } X_2 R_2) = \text{circuit } Q^2$

1. find min Q, unloaded $= \sqrt{230/33} = 2.64$ 2. Choose Q loaded (5)

4 3. ~~find~~ set $R_2 = R_1$

7. find $R_1 = R_g / Q^2 \sqrt{R_g/R_L} = 230 / 25 \sqrt{\frac{2.64}{239/33}} = 3.48\,\Omega$

8. $R_2 = R_1 = 3.48\,\Omega$

8 $X_L = Q(R_1 + R_2) = 5(6.96) = 34.8\,\Omega$

$X_L = 2\pi f L$

9 find $L = X_L / 2\pi f = 34.8\,\Omega / 6.28 \times 25 \times 10^3\ c/s = 157 \times 10^3 = .0222 \times 10^{-3} = 22.2$ MH

25 kc

~~22 MH~~ for f = 25 kc

or given L, find freq: $f = \frac{X_L}{2\pi L} = \frac{34.8\,\Omega}{6.28 \times .022} = 251\ c/s$ L = 22 MH

10 find $X_1 = \frac{\sqrt{R_g/R_L}}{\sqrt{R_g/R_L}+1} \times X_L = \frac{2.64}{3.64} \times 34.8 = 25.2\,\Omega$

11 $X_2 = X_L - X_1 = 34.8 - 25.2 = 9.6\,\Omega$

12 find $C_1 = \frac{1}{2\pi f X_1} = \frac{1}{6.28 \times 2.51 \times 10^2 \times 25.2} = \frac{1}{396 \times 10^2} = .00253 \times 10^{-2} = 25.3 \times 10^{-6}$ F

13 $C_2 = \sqrt{\frac{R_g}{R_L}}\, C_1 = 2.64 \times 25.3 = 66.6$ MF

14 Consider extra loss of coil Q = 30, $X_L = 34.8\,\Omega$ $R_{loss} = \frac{X_L}{Q} = \frac{34.8}{30} = 1.2\,\Omega$

Net work loss = 1.2 Ω compared to 6.96 Ω

8.16 Ω E Energy 1.2 Ω loss 3.48 6.96 3.48

$E = 6.96/8.16 = .85$ of E

$P \approx \frac{E^2}{R}$ $E^2 = .74$

Power efficiency = 74%

Note: To make cheap L = 2 mh, remove turns from 22 MH toroid. Until sec voltage as x former drops from by $\sqrt{\pi}$ I drops to 0.3 initial value. So ~~Com Assn~~ easily obtained capacitors can be used.

2.3 2 6 25 kc MF

π net design

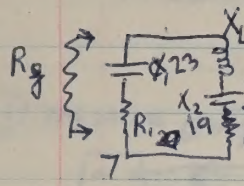
3/13 (1) of (3)

π net design for max power transfer ($R_1 = R_2$, $X_1 + X_2 = X_L$)

$X_1 \approx \sqrt{R_1 R_g}$ $X_2 \approx \sqrt{R_2 R_L}$ Tank Q loaded = $X_L / R_1 + R_2$

given $R_g = 80\Omega$, $R_L = 50\Omega$, $f = 7$MC, $Q_{unloaded} \approx$ ~~11~~ 50

min $Q_{loaded} \stackrel{?}{=} \sqrt{R_g / R_L} =$



1. find min Q loaded = $\sqrt{80/50}$
2. choose Q loaded. (3)
3. ~~find R_1 given R_g~~ $R_1 \approx R_g / Q^2 = 80/9 =$ ~~27Ω~~ 8.9Ω
4. Set R_2 equal to R_1 for max power transfer ~~=~~
5. ~~find $X_L = (R_1 + R_2) Q = (27+27)3 = 54.3 =$~~
6. find ratio $X_1 / X_2 = \sqrt{80/50} = \sqrt{R_g / R_L} = 1.26 : 1$ sum $X_1 + X_2 =$ ~~27~~ $Q(R_1 + R_2) = 2QR_1$
7. ~~find R_1~~ $= X_1 = 1.26 X_2$ $1.26X_2 + X_2 = 2 \cdot 3 \cdot R_1$ $R_1 = \frac{2.26 X_2}{6} =$ (.376 X_2)

   ~~$R_2 = (R_1) = .376 X_2 = (.376)^2 R_L = .0141 \times 50 =$ (7Ω)~~
8. find $X_L = Q(R_1 + R_2) = 9(7+7) =$ (14Ω) $\times 3 =$ (42Ω)
9. find L $X_L = 2\pi f L$ $L = X_L / 2\pi f = 14$~~42~~Ω $/ 6.28 \times 7 \times 10^6 =$ ~~0.95~~ 0.95×10^{-6} H
10. find X_1 $X_1 + X_2 = 42$ $X_1 = 1.26/2.26 \times 42 = 23.4\Omega$
11. find X_2 $42\Omega - 23.4\Omega = 19\Omega$

    42 − 23 = 19
12. find C_1 $X_C = \frac{1}{2\pi f C}$ $C_1 = \frac{1}{2\pi f X_1} = \frac{1}{6.28 \times 7 \times 10^6 \times 23.4\Omega} = .0097 \times 10^{-6} =$ (970 pF)
13. find $C_2 = 1.26 \times C_1 = 1.26 \times 970 =$ (1,220 pF) 1030

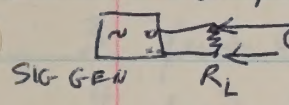
7. perhaps $R_1 = R_g / (Q\sqrt{R_g/R_L})^2 = 80 / 9^2 \times 1.26 =$ (7.05Ω)

   $R_2 = R_L / 9^2 \cdot 1.26 = 50 / 7.13 =$ (7.01Ω)

3/12/73

Heath Audio Gen Model IG-72

① Measure output R at 1 KC, conditions: +10 V range
f = 1Kc
attenuator full C.W.



① Max. $P = E^2 / R$

Power transfer experiment to determine internal resistance of audio generator

E	E^2	R	$P = E^2/R$
~~8.0V~~ ~~7.5V~~		∞	
4.6V	21.1	330Ω	0.064 w
5.9V	34.8	660Ω	.053
3.4V	11.6	165Ω	.070 w
2.43		100Ω	.059w
3.9		200Ω	.076
~~4.7~~		300	

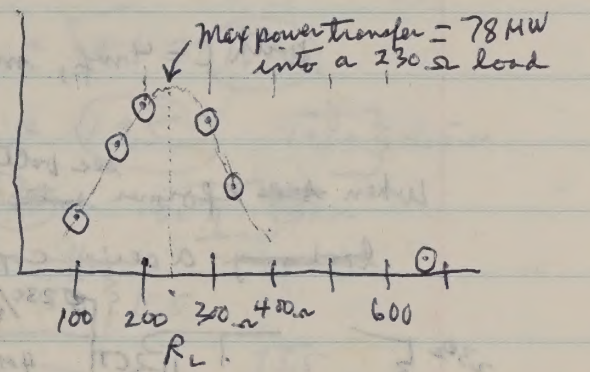


FIG 1 Power Transfer from generator to ~~load~~ various load resistances

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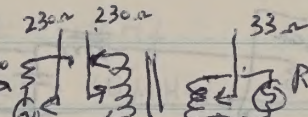
② Design of transformer to light a lamp (~~#~~ GE No. 49, 2.0V, 60 MA)

0.4V ← First Try to light lamp from ~~output of~~ audio generator:

Ⓐ Can be a step down transformer ~~from~~



$R = \frac{E}{I} = \frac{2.0V}{0.06A} = 33.\Omega$

Turns Ratio = $\sqrt{\text{impedance ratio}} = \sqrt{\frac{230\Omega}{33\Omega}} = 2.64:1$

design: Pri. inductive reactance must be at least 3 times the desired 230Ω input Z at desired freq of operation for efficient transformer action at desired freq.

$X_L = 3 \times 230\Omega \geq 690\Omega$ at 1KC

$X_L = 2\pi f L$
$L = \frac{X_L}{2\pi f}$

$L = X_L / 2\pi f = 690 / 6.28 \times 1{,}000 c/s \geq 0.0110$ henry

Solution: Try a 88 mH telephone Company C.T. toroidal coil as a 2:1 auto transformer

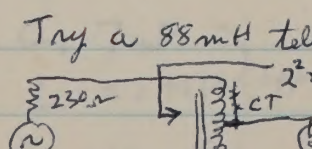


FIG 2

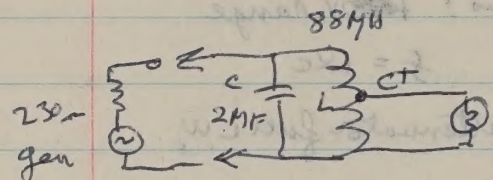
From graph, FIG 1, this should provide 63 MW to lamp if x former is 100% efficient at, and also operate efficiently at this frequency. (1Kc)

Performance: Lamp lit dimly + Measured voltage of 1.1V at 1KC
0.8V at 200 c/s
0.8V at 5 KC

(OVER)

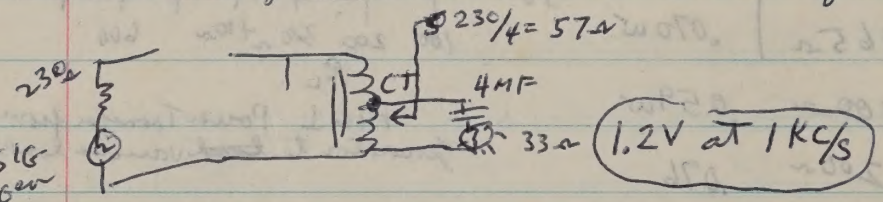
Tuned transformer:

a ~~T~~ x former may be used at lower frequencies if ~~the~~ tuned to resonance by a capacitor. A tuned x former requires less coil turns for a given frequency,

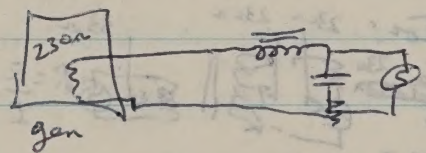


With C = 4mf, max out was 1.1V at f = 300 c/s

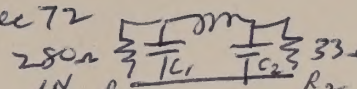
When ~~the~~ x former sec voltage ~~is~~ is too great for max power transfer, ~~battery~~ a series capacitor may be used for max power x fer.



"L" networks

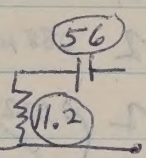


QST p 35 Dec 72

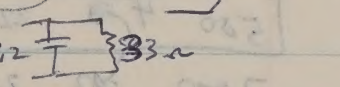


Step 0 draw π filter as above ← should be 230Ω

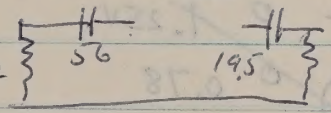
1. Find $Q_{min} = \sqrt{R_1/R_2} = \sqrt{280/33} = \sqrt{8.5} =$ (2.9)
2. Decide on Q for design = (5)
3. find $C_{1p} = R_1/Q = 280/5 =$ (56Ω)
4. find $R_{1S} = R_{1p}/Q^2 = 280/25 =$ (11.2)



5. Set $R_{2p} = R_{1S} = 11.2$
6. Find $Q = \sqrt{R_p/R_S} = \sqrt{33\Omega/11.2\Omega} = \sqrt{2.96} =$ (1.72)
7. Find $X_S = R_S Q = 11.2 \times 1.72 =$ (19.5Ω)
8. Find $X_p = R_p/Q = 33\Omega/1.72 =$ (19.2Ω)

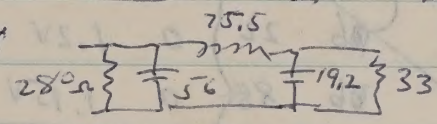


9. assemble 4 and 7.



10. Find inductor X_L = add 56 + 19.5 = (75.5Ω)

11. assemble 3 and 10 and 8



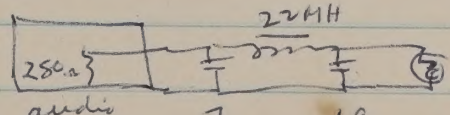
12. assign freq desired. = 1KC
13. Look up C_1 in reactance chart = 56Ω = 2MF
    L in " " = 75.5Ω = 10MH
    C_2 " " " = 33Ω = 5MF

1KC

10KC
C_1 0.3 μF
L 1MH
C_2 0.5μF

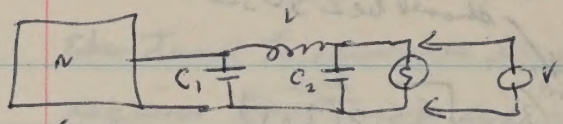
Find freq so as L = 22MH: = 1KC × $\frac{10\text{ MH}}{22\text{ MH}}$ = (455 c/s)

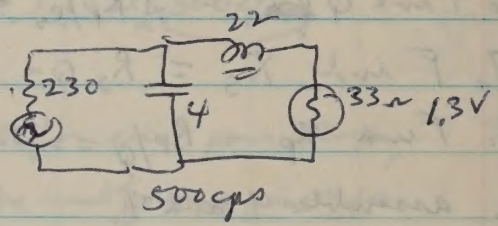
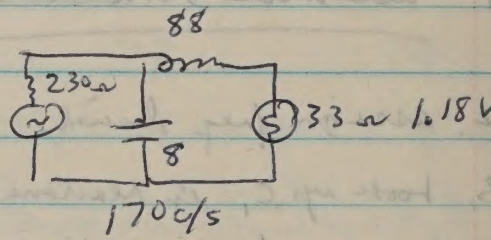
455 c/s
C_1 7μF
L 22MH } approx
C_2 10μF



(over)

Trial + Error:



f

	f	C_1	L	C_1	V
π	~~300~~	2	.088 H	2	0.8
π	700	2	0.022H	2	1.2V
π	700	2	0.022	4	1.2V
π	240	4	.088	2	1.0V
π	500	4	22	2	1.25V
L	500	4	22	0	1.3V
L	700	2	22	0	1.25V
L	300	2	88	0	0.78
L	240	4	88	0	1.0V
L	400	6	22	0	1.2V
L	200	6	88	0	1.15V
L	170	8	88	0	1.18V
L	340	8	22	0	1.0
π	500	4	22	4	1.15